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SURVEYS OF THE INTESTINAL PROTOZOA OF MAN, IN HEALTH AND DISEASE

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EVER since the discovery of *Balantidium coli* in the intestine of man by Malmsten in 1857, more or less interest has been exhibited in this and other species living in the same habitat. For the most part the organisms observed have been recorded from cases of dysentery, diarrhea and other diseases of the intestinal tract, but they have also been found in apparently healthy persons who may act as carriers. A number of investigations have been published, especially since 1914, that add to our knowledge of the distribution of the intestinal protozoa and the extent of infection by them among healthy persons in various parts of the world, as well as among patients suffering from intestinal disorders. Most of these surveys were undertaken with soldiers either in the war zone or in hospitals after their return from the war zone. A few surveys have been made with soldiers before leaving their native country and with civilians, mostly in hospitals. That our knowledge of this subject is still far from satisfactory is evident from a review of the literature. Many species have been seen only once or a few times and hence are not definitely established as such; others seem to be determined satisfactorily but are of doubtful pathogenicity; the life histories of none of the species are sufficiently known to render control measures effective; methods of infection are suspected but not definitely ascertained; the therapeutic agents available are very limited in their application and for most species none is known; and the actual distribution of the different species in health and disease among the general population, with respect to age, sex, race, occupation, etc., is still to be determined.

The principal species of protozoa which have been described from the intestine of man are, among the Sarcodina, *Entamoeba histolytica*, *Entamoeba coli* and *Endolimax nana*; among the Mastigophora, *Giardia (Lamblia) intestinalis*, *Trichomonas intestinalis*, and *Chilomastix*

(*Tetramitus*) *mesnili*; among the Sporozoa, *Isospora hominis*, *Eimeria wenyoni*, and *Eimeria oxyspora*; and among the Infusoria, *Balantidium coli*.

Due to the inaccuracy of present knowledge, there is much controversy as to the pathogenicity of many of these parasites. *Entamoeba histolytica* and *Balantidium coli* are parasites of well recognized pathogenicity. *Entamoeba coli* is a well known parasite that is non-pathogenic. Among the parasites of disputed pathogenicity are *Giardia intestinalis*, *Trichomonas intestinalis*, and *Chilomastix mesnili*; in certain localities these three parasites are very common and are supposed to cause severe diarrhea, especially in children. Many of the rare or recently described parasites are of doubtful pathogenicity; there are at least twenty-five species of these, belonging principally to the classes Sarcodina, Mastigophora and Infusoria.

There are also certain bodies which have been frequently found in the feces which are believed by some workers to be stages in the life history of protozoa. The most common of these are *Blastocystis hominis*, which has been confused with various cysts and has been described as the encysted stage of *Trichomonas intestinalis*, and iodine bodies of *I-cysts*.

Statistics from many countries prove that the dysenteries and diarrhoeas are very important causes of death and are especially so in the tropical islands. It cannot be claimed that a majority of these cases are of protozoal origin. It is a fact, however, that we know too little about the causes of these affections and their prevention and treatment. Without knowledge of the real causes and of the methods of diagnosis, efforts at therapy and prophylaxis must be conducted blindly. It appears highly important that we should have more complete knowledge of the origin of conditions which are causing such a large part of our total deaths. Furthermore, the relation between intestinal protozoa and intestinal disturbances that do not cause death nor receive medical attention is in urgent need of investigation. The wide distribution of species of parasites that are passed by unnoticed is evident from a recent study of children in a Baltimore hospital. Here children who were confined for reasons other than the presence of intestinal disturbances were found on careful examination to be infected in a high percentage of cases with an intestinal flagellate, *Giardia intestinalis*.

A review of over thirty-five papers published by American, English and French investigators during the years 1916 to 1919 describing the results of protozoan surveys has been made by the writers. These reports are based on studies made on all fronts during the war, on examinations of soldiers invalided home for various causes, and on material obtained from various classes of men, women

and children who had never been out of their native land. Most of the latter were either recruits or were confined in insane hospitals or other institutions. Although many of these surveys were not carried out as thoroughly as is desirable they furnish very interesting data and point the way for further research.

Multiple infections, that is, infections with more than one species of parasitic protozoon, seem to be quite common. Thus, Fantham found among 1305 soldiers, 18 cases of multiple infection with *Entamoeba coli*, *Giardia intestinalis* and *Blastocystis hominis*, 20 cases with *E. coli* and *B. hominis*, 20 cases with *G. intestinalis* and *B. hominis*, and several with *E. histolytica*, *E. coli*, *G. intestinalis*, *B. hominis* and a spirochete. Similar conditions were observed by Carter, Mackinnon, Matthews, and Smith who recorded 14 different combinations in multiple infections; by Hall, Adam and Savage who reported from 388 convalescent soldiers, 21 with *E. histolytica* and *E. coli*, 12 with *E. histolytica*, *E. coli* and *G. intestinalis* and 9 with *E. coli* and *G. intestinalis*.

Among the rarer intestinal protozoa the coccidian, *Isospora hominis*, is of particular interest. This species was practically unknown before 1915 (Wenyon) but was found in no less than one-third of the surveys undertaken since then. Two new species of coccidians have also been added to those living in man, *Eimeria wenyoni*, and *E. oxyspora* (Dobell).

The percentage of infection with the more common intestinal protozoa among the twenty thousand cases examined is approximately as follows: *Entamoeba coli*, 20 per cent; *Giardia intestinalis*, 12 per cent; *E. histolytica*, 9 per cent; *Chilomastix mesnili*, 4 per cent; and *Trichomonas intestinalis*, 3 per cent.

One of the most surprising results revealed by the surveys under review is the high rate of infection with *Entamoeba histolytica* among classes who had never been out of their own country or who were not suffering from intestinal disturbances, as compared with patients who had or were convalescing from dysentery and diarrhea. Thus Woodcock recorded 1.9 per cent of infection with *E. histolytica* among dysenteric Indian soldiers, and 20 per cent of infection among Indian soldiers in hospital for other complaints; Smith and Matthews found 7.5 per cent of *E. histolytica* among 200 non-dysenteric soldiers; Yorke obtained from 1763 people who had never been out of England, 19.5 per cent of infection with *E. histolytica* among inmates of an insane hospital, 5.2 per cent among army recruits, and 1.5 per cent among civilians in a general hospital; Wenyon and O'Connor reported 5.3 per cent infection with *E. histolytica* among healthy men in camps, 13.7 per cent among healthy natives in prison, and 6.4 per cent among convalescent soldiers; MacAdam and Keelan recorded

10.1 per cent infection with *E. histolytica* among dysenterics, 13.6 per cent among non-dysenterics and 17.8 per cent among convalescents; Baylis (1919) concluded from an examination of 400 healthy new entries to the Royal Navy that from 1 to 5 per cent of healthy carriers of *E. histolytica* exist in England; Kofoid, Kornhauser and Plate found a greater percentage of infection among overseas troops (10.8 per cent) than among home service troops (3.0 per cent). In certain cases also the records indicate a difference between the infectivity of different races. For example, Boulenger reported almost twice as many cases among Indian as among British troops in Mesopotamia. Thus acute Indian dysenterics showed 48.1 per cent of infection whereas acute British dysenterics, only 24.8 per cent, and non-intestinal Indians 10.5 per cent of infection and non-intestinal British, 6.5 per cent. The results obtained by the various investigators indicate how wide spread are the healthy carriers of *E. histolytica* and other intestinal protozoa. They also show how desirable are thorough surveys of both healthy and diseased persons in the general population.

It is hoped that discussions such as that presented in this paper will stimulate investigations of the intestinal protozoa and for this reason the following brief statements regarding the purposes and methods of conducting surveys of intestinal protozoa are included.

Surveys of intestinal protozoa are desirable in order to add to the present medical knowledge of the incidence of each species according to geographic range, age, race, and occupation. Our present knowledge of the incidence of the intestinal protozoa is based largely on surveys conducted among troops, the majority of whom had suffered from dysentery or diarrhea of some type. We now require more complete information about the incidence of these species among the general population. The examination of specimens from Maryland and other Southern States by workers in the Department of Medical Zoology of the School of Hygiene and Public Health of the Johns Hopkins University has revealed a high percentage of infection with some of these parasites. A remarkably high infection is indicated also by the reports from the Division of Parasitology of the California State Board of Health as published in their Monthly Bulletin. Data regarding the association of the various species, one with another, and with other entozoa are also much needed.

The degree of pathogenicity of the various species is still undetermined and little is known of the lesions caused by any of them except *E. histolytica*. In a survey valuable information may be obtained by systematic observation of the bowel condition, the blood picture, the nutrition, and the evidence of the presence of toxic substances as shown by disturbances of circulatory, nervous, or other

systems. Furthermore a protozoan survey would add to the present zoological knowledge of species and their differentiation, and life cycles, especially as they bear on preventive measures, and as regards the appearance of cysts in stools.

Men need to be trained if practical work on the diseases which are transmitted by soil pollution is to be carried on. Before such training can be given we must perfect methods of diagnosis, and investigate the factors involved in prevention. The attention of physicians must be directed to the prevalence of these parasites, thereby stimulating clinical work on pathogenesis and therapy.

The character of the population and the interests of the investigator determine the method of conducting a survey of intestinal protozoa. It is possible, however, to present certain principles that apply to almost any type of survey. If there is sufficient time and enough assistance is provided, a survey of the general population may be made; but it seems best to limit the work to certain classes. These may be selected according to habitat, race, age, occupation, or physical condition. The number of cases necessary to give satisfactory results cannot be stated with certainty but an attempt should be made to examine at least 1000 of each class. The results of various investigations have shown that three examinations of each case give the greatest return for the effort involved. Perhaps the easiest cases to study are those confined in hospitals, insane asylums, and similar institutions. It is desirable however that we know the relation between the intestinal protozoa and the healthy civilian in order to determine the percentage of carriers and their connection with the dissemination of parasites. Another class that is badly in need of investigation comprises the children with intestinal disorders not of sufficient severity to warrant hospital treatment.

Attention should also be directed toward the study of new species and the supplying of additional information regarding those already discovered and named. Such species are almost certain to be encountered in any survey and afford an opportunity to enlarge our knowledge of the group.

Studies of the effects of therapy should be included wherever possible. The control of protozoan diseases depends in large part on the success of these studies. That this subject is recognized as important is evident to anyone who examines the literature on intestinal protozoa that has appeared within the past few years.

The conditions affecting the transmission of diseases caused by intestinal protozoa are also open for investigation. We think we know how transmission takes place, but have very little data on which to base our beliefs. The most important factors involved in their study are probably soil pollution, contact, and insects and other animals.

The viability of cysts under various conditions of excreta disposal offers a simple and important problem for research.

Records should of course be made of each case and should include the name, sex, race, age, occupation and sanitary surroundings of the patient; important facts of clinical history such as dysentery and diarrhea; abnormal features noted on physical examination; and reports on treatment and their effects.

To make a survey as effective as possible it is desirable to properly prepare and preserve for future reference specimens of the parasites found. The best preparations result from the use of Schaudinn's alcoholic-sublimate iron-haemotoxylin method.

The methods of fecal diagnosis employed depend somewhat on the accuracy of the results desired and the ability to obtain and use special apparatus. The Donaldson iodine-eosin-smear method seems to be the quickest and easiest. Concentration methods give a slightly higher percentage of positives and the Schaudinn iron-haemotoxylin smear method just mentioned is very useful in checking up doubtful cases.

Species of protozoa resembling those that occur in the intestine of man are also present in the lower animals and one who wishes to undertake a protozoan survey will find it helpful to become acquainted with these before undertaking human fecal diagnosis. Parasitic amoebae inhabit the intestine of the cockroach, the frog and the oyster; *Giardia* is common in the intestine of rats; *Trichomonas* is abundant in the intestine of the frog; *Balantidium* occurs in the frog and pig; and *Coccidia* are very frequently present in rabbit feces.